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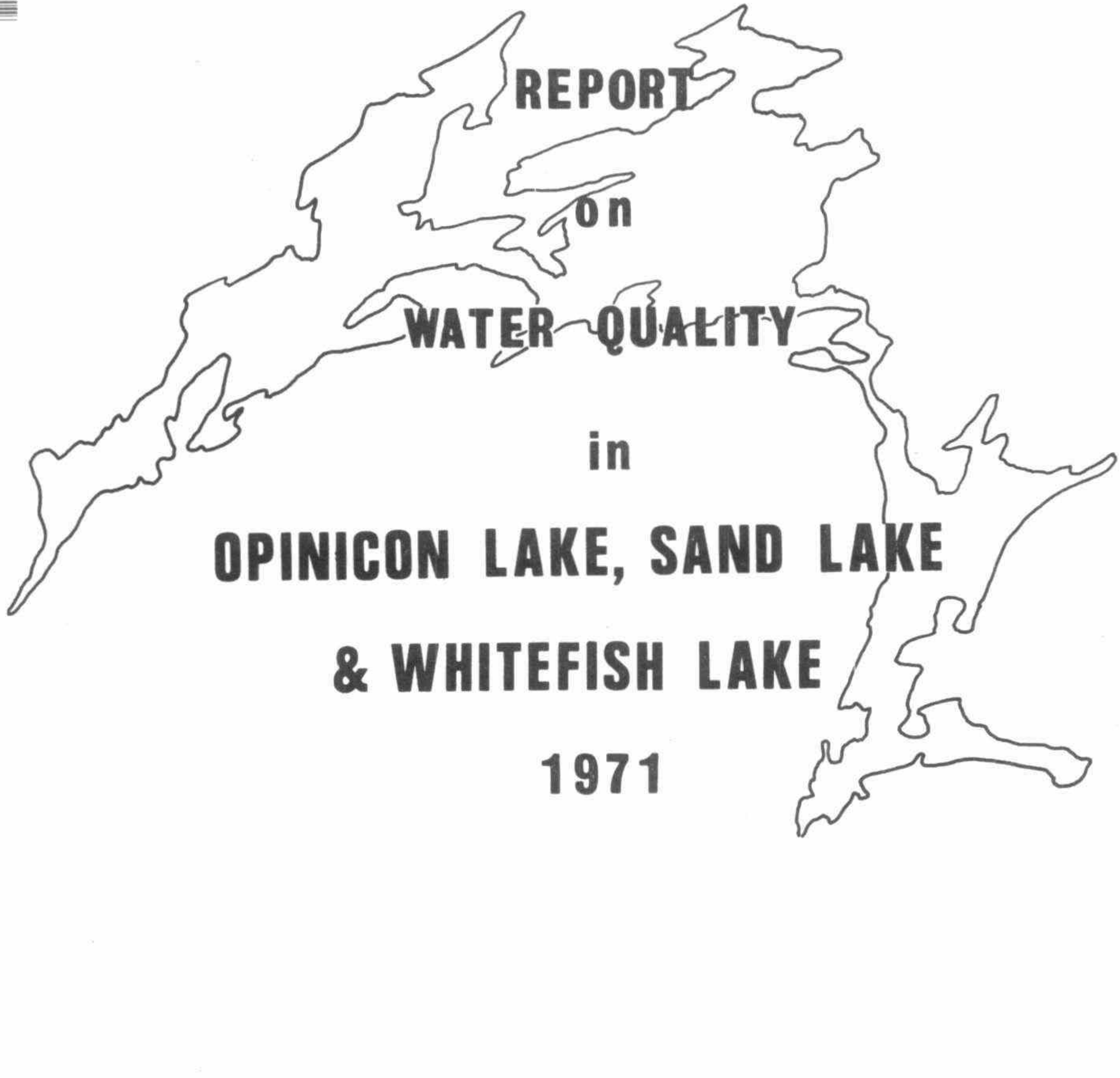

REPORT

on

WATER QUALITY

in

OPINICON LAKE, SAND LAKE
& WHITEFISH LAKE

1971

RECREATIONAL LAKES PROGRAM

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Report on water quality in
Opinicon Lake, Sand Lake and
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THE
ONTARIO WATER RESOURCES COMMISSION
REPORT

ON
WATER QUALITY
IN
OPINICON LAKE, SAND LAKE AND WHITEFISH LAKE

1971

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SUMMARY

Opinicon, Sand and Whitefish lakes lie in the physiographic region known as the Frontenac Axis. This region of Precambrian bedrock is characterized by a moderately to steeply sloping terrain with shallow to no soil cover and is generally well drained. In most instances the soil cover is less than the 1.5 meters (5 feet) required by the Ministry of the Environment for the installation of standard, subsurface septic tank systems.

In Opinicon and Whitefish lakes, water temperatures were generally uniform with depth. In contrast, a well-defined thermocline or zone of rapid temperature decline was observed between the warm upper waters (eplimnion) and the cool bottom strata (hypolimnion) of Sand Lake. Depressed oxygen levels and elevated carbon dioxide concentrations resulting from decomposition of organic matter characterized the deep-waters of Sand Lake. In contrast, the entire water mass in Opinicon and Whitefish lakes was generally well-oxygenated indicating the effects of wind-induced vertical mixing processes. During the latter part of June in Opinicon Lake and throughout the entire survey in Sand Lake, deep-water dissolved oxygen concentrations were very low.

Surface values for pH were higher than bottom-water recordings while deep-water alkalinity concentrations were generally higher than those of the upper strata. The water is relatively hard but does not have any unusual mineral characteristics.

Concentrations of Kjeldahl nitrogen and total phosphorus were low and would not be expected to support nuisance levels of algae.

Algal levels as measured by chlorophyll a concentrations were low during the three surveys. The algal densities recorded in the three lakes would not be expected to reduce water-oriented recreational activities such as swimming and water skiing or diminish the aesthetic quality of the lakes.

Opinicon, Sand and Whitefish lakes generally had good bacteriological water quality well within the OWRC recreational use criteria during the three survey periods.

In Opinicon Lake, the area around the inflow from Chaffey's Lock had higher FS and TC levels indicating a bacterial input. In June and October the fecal streptococcus (FS) level exceeded the OWRC recreational use FS criterion.

The bacterial levels in Sand Lake were generally higher than those in either Opinicon or Whitefish lakes.

Station 34 in Whitefish lake had consistently high FS levels that exceeded the OWRC criterion during all three surveys. However, similar increases in TC and FC levels did not occur indicating that the high FS means were not due to a domestic sewage input but do indicate an external contaminating source.

In view of the existing good water quality which for the most part characterizes the waters of the Opinicon lakes, every effort should be made to prevent any direct flow or leachate from domestic waste disposal systems or other potential sources of pollution from gaining access to the lakes.

INTRODUCTION

Maintenance of good water quality in recreational lakes in the Province of Ontario is of vital concern to the Ontario Ministry of the Environment and other governmental agencies involved in tourism and the control and management of shoreline development of cottages and resorts. In 1970 an interdepartmental program was established to survey a number of recreational lakes in order to detect and correct sources of water pollution and ensure that our lakes would be well managed to protect water quality. The Ontario Department of Health, whose jurisdiction in this program was transferred to the Ministry of the Environment in December 1971, would carry out on-shore inspection and correction of faulty private waste disposal systems, whereas the Ontario Water Resources Commission (now within the Ministry of the Environment) would evaluate the existing water quality of the respective lakes. A record of the present status of the private waste disposal systems and the lake water quality would also be documented for comparative use in any future studies.

Recreational lakes are subjected to two major types of water quality impairment; bacteriological contamination and excessive growths of algae and aquatic weeds (eutrophication). The two problems may result from a common source of wastes but the consequences of each are quite different. Bacteriological contamination by raw or inadequately treated sewage poses an immediate public health hazard if the water is used for bathing. In order for this to occur, raw wastes or septic tank effluents must gain entry to the lake although it may not be obvious upon visual inspection of the site. It must be noted that no surface water is considered safe for human consumption without prior treatment including disinfection. The algae and weed growths impair aesthetic values and recreational use of a lake but seldom pose a health hazard. There are nutrient sources other than sewage wastes which do not create serious bacterial hazards but do support nuisance plant growths such as agricultural fertilizer losses and normal nutrient runoff from forest and field.

In order to carry out its responsibility of evaluating the status of water quality in recreational lakes, the Ontario Water Resources Commission undertook a study on Opinicon Lake (including Sand and Whitefish lakes) in the summer of 1971. Three surveys were conducted; a spring survey from June 24 to 28, a mid-summer survey from August 19 to 23 and a fall survey from October 5 to 9 inclusive. These studies included the assessment of bacteriological, physical, chemical and biological conditions of the lake with stress being placed on the bacteriological and nutrient enrichment problems.

Sampling surveys were conducted on an intensive basis (sampling each day for a minimum of five days) which is mandatory for a reliable assessment of bacteriological conditions.

In addition to the results obtained from these studies, information from other governmental agencies has been incorporated in this report which is the Ontario Water Resources Commission's contribution to the Interdepartmental Task Force Report which will deal with the overall cottage pollution program in Ontario.

AREA DESCRIPTION

Geography and Topography

Opinicon, Sand and Whitefish lakes are located in a narrow neck of Precambrian rock known as the Frontenac Axis which links the Laurentian Shield to the Adirondacks of New York State. This Precambrian rock which is comprised of crystalline limestone and various schists and gneisses forms the shoreline of these lakes. The soil cover surrounding the lakes in most instances is less than the 1.5 meters (5 feet) required by the Ministry of the Environment for the installation of standard subsurface septic tank systems. The shoreline is generally moderate to steep sloping while the lake bottom tends to have a gentle slope. The forested areas are generally of a mixed type with predominantly white pine and white birch. Aquatic vegetation is common throughout these lakes.

Opinicon Lake lies in the townships of two counties and located approximately 40 kilometers (25 miles) north of Kingston. The majority of the lake lies in South Crosby Township, County of Leeds, with the western one-quarter of the lake lying in the Townships of Bedford and Storrington in Frontenac County.

Opinicon Lake has a water surface area of 7.8 square kilometers (1,940 acres) with a shoreline length, including islands, of 52 kilometers (32 miles). The lake has a maximum depth of 9.1 meters (30 feet) and an average depth of 4.9 meters (16 feet).

The bedrock around the lake is composed of two types of Precambrian rock. The first type, consisting of gneisses and schists, dominates the south shore west of Davis Lock. The remainder of the bedrock around the lake consists of crystalline limestone. The soil cover around the shoreline is generally rockland or the Monteagle sandy loam-rock soil complex which consists of a shallow, well drained sandy loam till with frequent rock outcrops. There is a small area of Uplands sand which is a shallow, non-calcareous, well drained sand in the vicinity of Cow Island. Peat dominates the shoreline east from Sugarbush Island.

Sand Lake lies in South Crosby Township, County of Leeds, and is downstream of and directly connected, via Davis Lock, to Opinicon Lake.

Sand Lake has a water surface area of 7.3 square kilometers (1,810 acres) and a shoreline length of 52 kilometers (32 miles). The maximum recorded depth of the lake is 14 meters (47 feet) and the mean depth is 5 meters (17 feet).

The bedrock around Sand Lake is the same as the two types of Precambrian bedrock surrounding Opinicon Lake. The gneisses and schists dominate the south shore while crystalline limestone underlies the remainder of the shoreline. The Monteagle sandy loam-rock soil complex covers the south shore of the lake from Davis Lock to Jones Falls including Birch Island. The northern shoreline from Davis Lock to Myers Bay, with the exception of Freeman Bay, is classified as rockland. The shoreline around Freeman Bay is an area of poorly drained organic soil. South from Myers Bay the shoreline cover is known as Uplands fine sandy loam-rock soil complex which is characterized by a shallow, well drained, non-calcareous sandy loam with frequent rock outcroppings.

Whitefish Lake lies in the Townships of South Crosby and Rear of Leeds and Lansdowne in Leeds County and is downstream of and directly connected, via the locks at Jones Falls, to Sand Lake. It has a water surface area of 4.1 square kilometers (1,008 acres) and a shoreline length of 35 kilometers (21.7 miles). The maximum recorded depth of the lake is 5.8 meters (19 feet) and the mean depth is 2.8 meters (9 feet).

As with Opinicon and Sand lakes, the bedrock is of two types of Precambrian rock. Gneisses and schists dominate the west shore of Whitefish Lake while crystalline limestone underlies the east shore. The east shore is classified as rockland although there is an area of Seeleys Bay silt loam which is a calcareous, well drained, silty clay loam extending south from Judas Island into Pierces Flow.

Climate Range

The Opinicon, Sand and Whitefish lakes area has a mean annual temperature of 6°C (43°F) and a mean annual precipitation of 86 centimeters (34 inches) including 203 centimeters (80 inches) of snow. The January and July mean daily temperatures are -9°C (16°F) and 20°C (68°F) respectively. According to meteorological reports the area enjoys over 200 days with no measurable precipitation. The summer climate is conducive to most recreational activities and the winter with its abundance of snow provides for participation in most winter sports.

Water Movement

Opinicon, Sand and Whitefish lakes are part of the Rideau Canal System. Their combined drainage basin is approximately 100 square kilometers (39 square miles) and flows into the St.Lawrence River Terminal Drainage Basin via the Cataraqui River. The lake levels and flows are regulated by the Federal Ministry of Transport.

Opinicon Lake has a drainage basin area covering 27 square kilometers

(10 square miles) and has three permanent inlets and one outlet. The major inlet is from Indian Lake and the flow is controlled by a combination of a lock and overflow weir at Chaffey's Locks. The other inlets are: Rock Lake Creek which drains Lower Rock Lake; and Hart Lake Creek which drains Hart and Crow lakes. The outlet which flows directly into Sand Lake is at Davis Lock where the lake level is controlled by an overflow weir.

Sand Lake has a drainage basin area covering 37 square kilometers (15 square miles) with one permanent inlet and one permanent outlet. The inlet is from Opinicon Lake with the flow regulated by an overflow weir at Davis Lock. The outlet flow and lake level are regulated by a combination of locks, an overflow weir and the powerhouse at Jones Falls.

Whitefish Lake has a drainage basin area covering 36 square kilometers (14 square miles) with one permanet inlet and two outlets. The inlet is at Jones Falls and receives water from Sand Lake. One outlet is an overflow dam discharging into Morton Creek at Morton. This overflow dam regulates the water level in Whitefish Lake. The major outlet is a portion of the Rideau Canal System and begins at Squaw Point.

Shoreline Development

Lying close to the border of the United States and being part of the Rideau Canal System has led to generally well developed shorelines on Opinicon, Sand and Whitefish lakes.

Opinicon Lake has approximately 120 cottages most of which are well distributed along all the shorelines with concentrations of cottages near Chaffey's Locks, Barrel Point and Davis Lock.

Sand Lake, with approximately 110 cottages, has a cluster type of shoreline development with concentrations in small areas such as around Ransier Bay, Powell Bay and between Myers and Glovers bays (Figure 1).

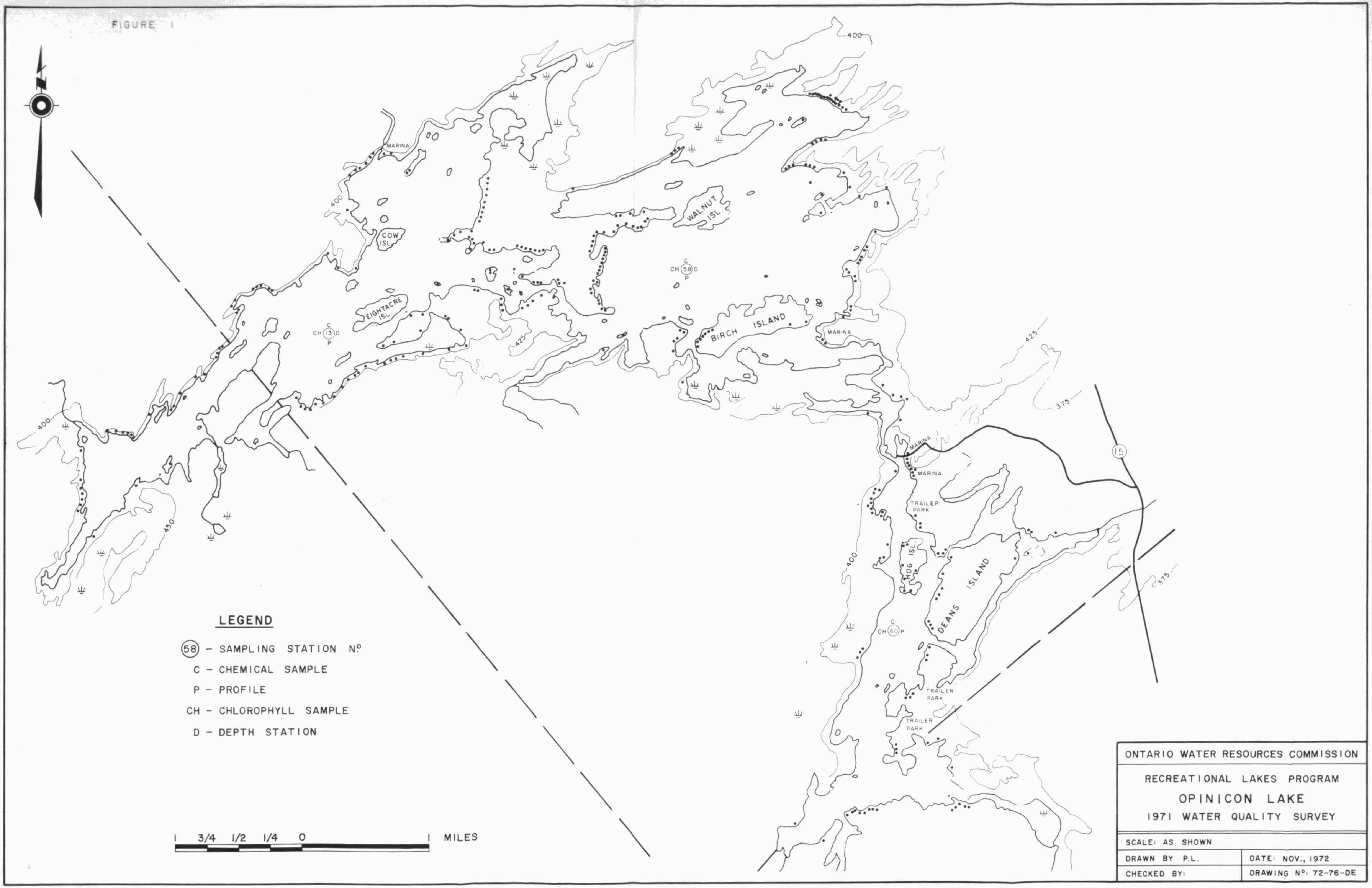
Whitefish Lake has approximately 100 cottages which are also of a cluster type of development. The areas of cottage concentrations in this lake are around Jones Falls, Deans Island and Squaw Point. The western shoreline is generally undeveloped (Figure 1).

Water Usage

The majority of the cottage owners use the lake water as their source of domestic supply. The lakes support recreational water sports such as fishing, boating on the Rideau Canal System, water skiing and swimming. According to the information available from the Department of Lands and Forests the most common game fish in these lakes are northern pike, walleye, largemouth and smallmouth bass.

There are no direct discharges of wastes into Opinicon, Sand or Whitefish lakes from communal or municipal sewage treatment facilities. There does not appear to be any pollution hazard from the operation of existing municipal solid waste disposal sites.

FIGURE 1



ONTARIO WATER RESOURCES COMMISSION

RECREATIONAL LAKES PROGRAM
OPINICON LAKE
1971 WATER QUALITY SURVEY

SCALE: AS SHOWN	
DRAWN BY P.L.	DATE: NOV., 1972
CHECKED BY:	DRAWING No: 72-76-DE

FIELD AND LABORATORY METHODS

Physical, Chemical and Biological Field Methods

Water quality surveys were conducted on Opinicon, Sand and Whitefish lakes from June 24 to 28, from August 19 to 22 and from October 5 to 10, 1971. Three mid-lake sampling sites, Station 13 (Opinicon Lake), Station 58 (Sand Lake) and Station 60 (Whitefish Lake) were chosen for physical, chemical and biological sampling (Figure 1).

Dissolved oxygen and temperature profiles were determined daily in the field using a combination dissolved oxygen-telethermometer unit. Total alkalinity and free carbon dioxide were measured daily titrimetrically and pH was measured with a portable pH meter. Daily, samples for chlorophyll analysis were collected in a 32-ounce bottle, at each mid-lake station, utilizing a composite sampler lowered through the euphotic zone (2X Secchi disc depth) and immediately preserved with 10-15 drops of a 2% $MgCO_3$ suspension.

Once per survey, a 32-ounce sample for hardness, alkalinity, chloride, total phosphorus, total Kjeldahl nitrogen, iron and conductivity was collected at all mid-lake stations. As well, at least two samples were collected at both the major inlet and outlet. The mid-lake stations were sampled using a composite sampler through the euphotic zone. At the outlet and inlet, samples were collected from 1 meter of depth using a Kemmerer sampler.

At each mid-lake station, one sample for total phosphorus, total Kjeldahl nitrogen and iron was obtained by means of a Kemmerer sampler from a depth of 1 meter above bottom on October 7.

Physical, Chemical and Biological Laboratory Methods

All analyses were carried out using routine OWRC methods based on Standard Methods 13th Edition.

Iron was measured after the sample had been digested with acid to dissolve all forms of iron present.

Kjeldahl nitrogen and total phosphorus concentrations were determined after the sample was digested with acid and an oxidizing agent to destroy organic matter.

For chlorophyll determinations, 1 litre samples were filtered through a 1.2 µ membrane filter which was then extracted with 90% acetone for 24 hours. Absorbance of the extract was determined at wavelengths of 600 to 750 µ using a Unicam SP1800 ultra violet spectrophotometer. The concentrations of chlorophyll a were calculated using the equation given by Richards & Thompson (1952).

Bacteriological Field and Laboratory Methods

Five-day intensive bacteriological surveys were completed in June, August and October on the Opinicon Lake area. Sixty-one surface samples and three depth samples at Stations 3D, 19D and 51D were taken daily.

Surface samples were collected at a depth of one meter below the surface using sterile, autoclavable polycarbonate 250 ml bottles. Depth samples were collected one meter above the bottom using a modified "piggy back" sampler and sterile 237 ml evacuated rubber air syringes.

All samples were stored on ice and delivered to the mobile laboratory within two to six hours and analyzed for total coliforms, fecal coliforms and fecal streptococcus using the membrane filtration technique (MF) (Standard Methods, 13th Edition) except that m-Endo Agar Les (Difco) was used for total coliform and MacConkey membrane broth (Oxoid) was used for fecal coliform determinations. The total coliforms (TC), fecal coliforms (FC) and fecal streptococcus (FS) were used as "indicators" of fecal pollution. The "indicators" are the normal flora of the large intestine, and are present in large numbers in the feces of man and animals. When water is polluted with fecal material, there is a potential danger that pathogens or disease causing micro-organisms may also be present.

The coliform group is defined, according to Standard Methods, 13th Edition, as "all of the aerobic and facultative anaerobic, gram-negative, non-sporeforming rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C" and, or "all organisms which produce a colony with a golden-green metallic sheen within 24 hours of incubation" using the MF technique. This definition includes, in addition to the intestinal forms of the _Escherichia coli_ group, closely related bacteria of the genera Citrobacter and Enterobacter. The Enterobacter - Citrobacter groups are common in soil, but are also recovered in feces in small numbers and their presence in water may indicate soil runoff or, more important, less recent fecal pollution since these organisms tend to survive longer in water than do members of the Escherichia group, and even to multiply when suitable environmental conditions exist. A more specific test for coliforms of intestinal origin is the fecal coliform test, with incubation of the organisms at 44.5°C. Though by no means completely selective for Escherichia coli, this test has proved useful as an indicator of recent fecal pollution.

Fecal streptococci (or enterococci) are also valuable indicators of recent fecal pollution. These organisms are large, ovoid, gram-positive bacteria, occurring in chains. They are normal inhabitants of the large intestine of man and animals, and they generally do not multiply outside the body. In waters polluted with fecal material, fecal streptococci are usually found along with coliform bacteria, but in smaller numbers, although in some waters they may be found alone. Their presence, along with coliforms, indicates that at least a portion of the coliforms in the sample are of fecal origin.

Bacteriological Statistical Methods

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial levels and this type of data is the geometric mean. The vast quantities of bacteriological data generated from these samples necessitated the development of additional statistical methods to summarize the mean results into a more concise presentation. The statistical methods used are based on the analysis of variance. The stations on the lake can be grouped, by this method, into areas or groups of stations within the same statistical bacterial level, without the bias normally associated with manual interpretation.

The analysis of variance is particularly effective where bacterial concentrations vary slightly throughout the lake. Areas or stations with slight differences in bacterial concentration may be isolated. Areas or stations with statistically higher bacterial numbers reliably indicate an input.

The results from all the analyses were organized as replicates representing the stations during the survey period. All data were transformed to logarithms (base 10) and all further analyses were done using these transformed data. A geometric mean (the antilogarithm of the average of the logarithm) was calculated on each station and for each parameter. The validity of the analysis of variance program (ANOVA-CRE; Burger, 1972), was based on the assumptions that the variances of all the stations were similar (Bartlett's test of Homogeneity) and that the data were normally distributed.

Both of these assumptions were checked on the Opinicon Lake area. The Bartlett's test was found to be non-significant and the data followed a normal distribution, hence the analysis of variance (F-test, Sokal, 1969) was calculated on all stations.

If the F was significant, then the multiple-t test was used to help determine the stations which should be deleted from the overall group to yield a homogeneous group of stations. The withdrawn stations were regrouped with respect to geographic proximity and similar means. The calculations on all groups were repeated using the analysis of variance program until each discrete group was homogeneous. The homogeneous groups that were geographically isolated compared by means of the Student-t test (using the log GM and S.E.) which indicated the statistical difference between these groups. The Student-t test was also used to compare the grouped bacteriological data from the three surveys.

DISCUSSION OF RESULTS

Temperature and Dissolved Oxygen

In June, water temperatures were homothermous or near-homothermous with depth in Opinicon and Whitefish lakes (Figures 2a and 4a respectively). A well-defined thermocline or zone of rapid temperature decline was apparent between 4 and 7m in Sand Lake (Figure 3a). This thermocline serves as a physical barrier to mixing between the upper warm strata (eplimnion) and the bottom cool strata (hypolimnion). Although thermal stratification was not apparent in Opinicon Lake, a severe dissolved oxygen depletion occurred between 4m (11.3 mg/l) and 9m (1.1 mg/l). In Sand Lake, dissolved oxygen concentrations declined through the thermocline (Figure 3a) and were as low as 1.5 mg/l at 1m above bottom. The deep-water oxygen deficits in Opinicon and Sand lakes resulted from bacterial oxidation of organic matter, biological respiration and chemical oxidation. Oxygen conditions in Whitefish Lake, the shallowest lake, were non-diminishing with depth, indicating the effects of wind-induced vertical mixing.

During the period August through October, the temperature and oxygen regimes in Opinicon and Whitefish lakes were generally similar between surface and bottom indicating complete vertical mixing from wind and wave action, (Figures 2b, 2c, 4b and 4c). By early October, the thermocline in Sand Lake was substantially lower than during the preceding surveys (Figures 3a, b and c). This phenomenon as well as the cooler surface water temperatures were in keeping with the expected seasonal changes characteristic of many small inland recreational lakes. Severe dissolved oxygen declines from 11.8 to 0.8 mg/l on August 21 and from 14.5 to 0.2 mg/l on October 5 were apparent through the thermocline (Figures 3b and c). During the latter part of June in Opinicon Lake and throughout the entire survey period in Sand Lake, deep-water dissolved

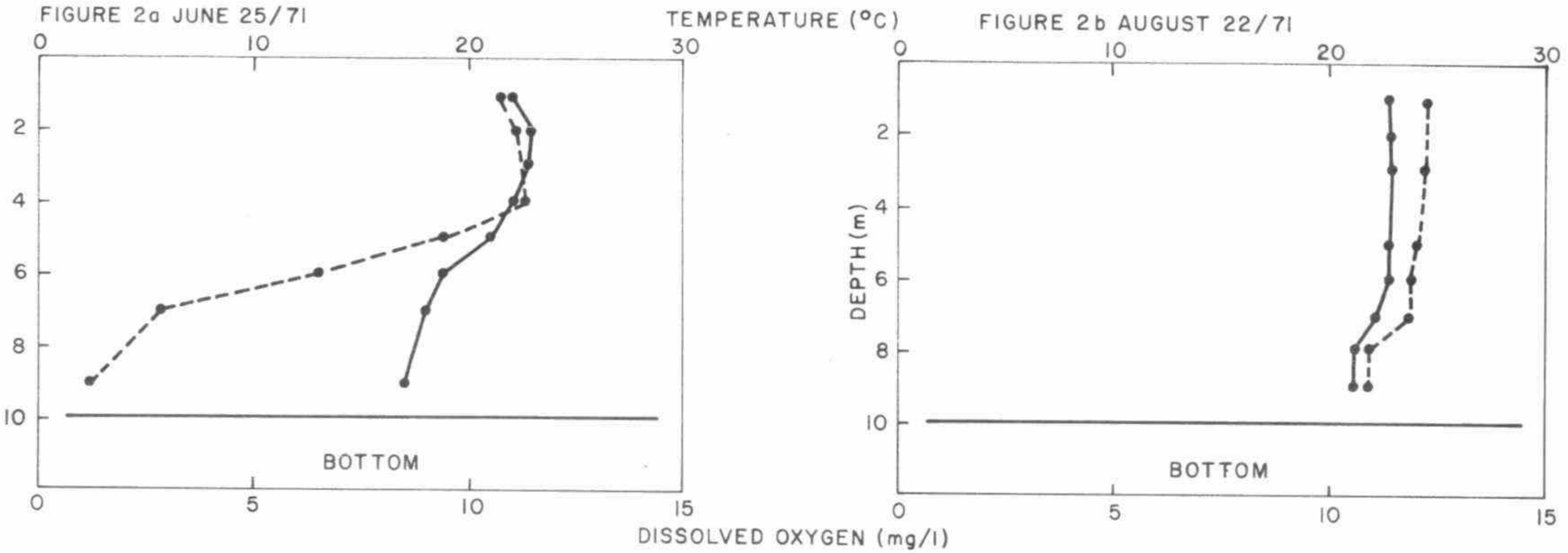
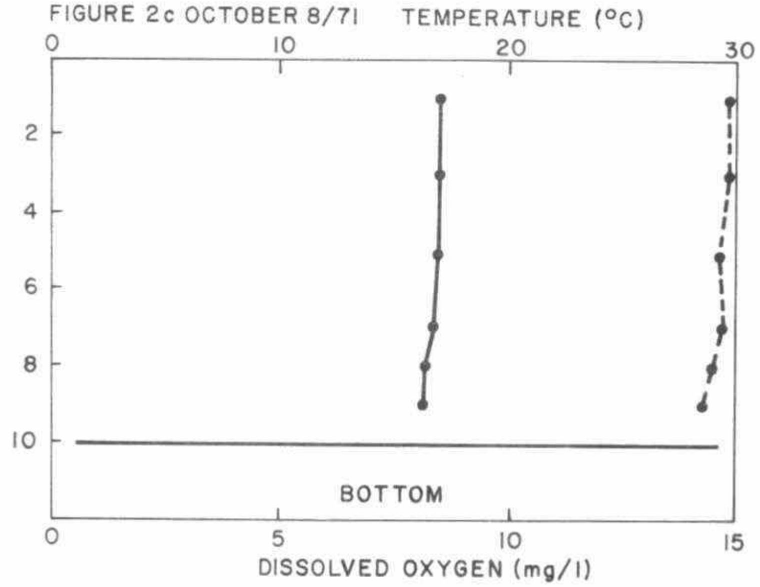


FIGURE 2: TEMPERATURE AND DISSOLVED OXYGEN PROFILES IN OPINICON LAKE STATION 13.



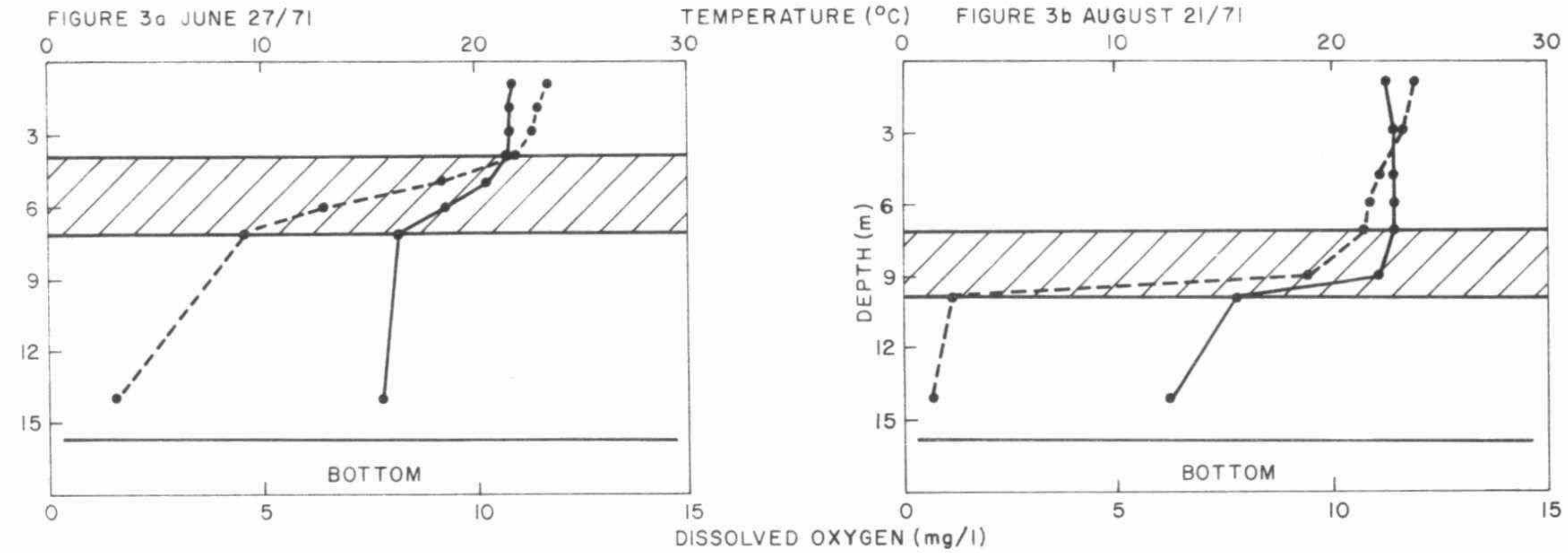


FIGURE 3a JUNE 27/71

FIGURE 3b AUGUST 21/71

FIGURE 3: TEMPERATURE AND DISSOLVED OXYGEN PROFILES IN SAND LAKE STATION 58. THE SHADED AREA APPROXIMATES THE POSITION OF THE THERMOCLINE.

●——● TEMPERATURE
●- - -● DISSOLVED OXYGEN

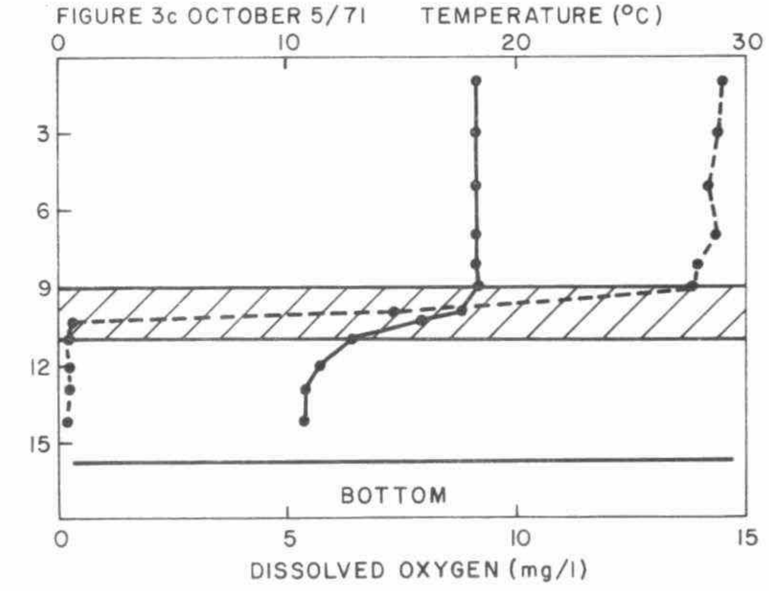


FIGURE 3c OCTOBER 5/71

FIGURE 4a JUNE 25/71

FIGURE 4b AUGUST 22/71

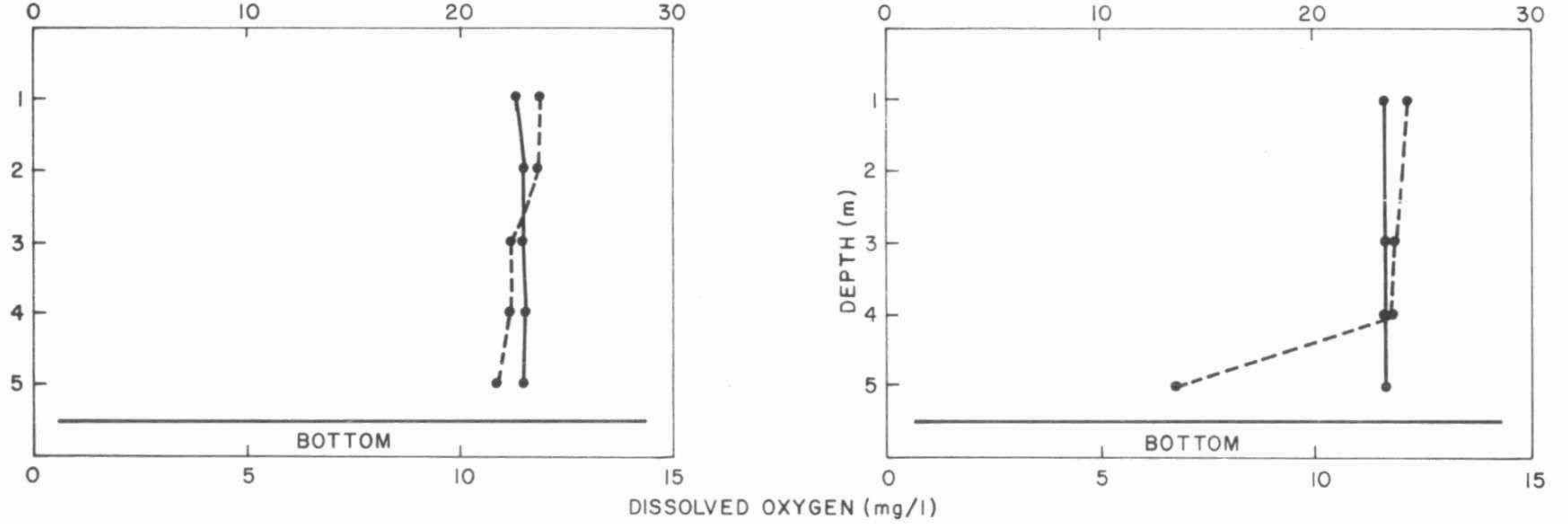
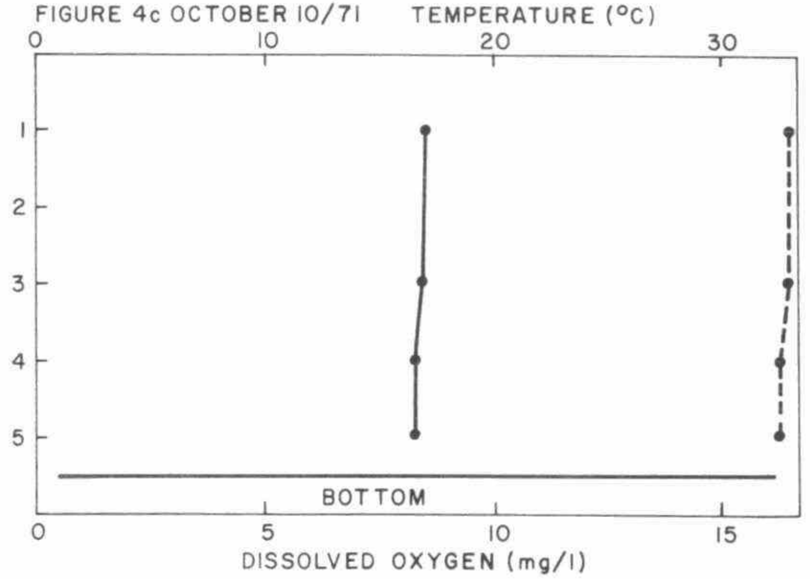


FIGURE 4: TEMPERATURE AND DISSOLVED OXYGEN PROFILES IN WHITEFISH LAKE STATION 60.

FIGURE 4c OCTOBER 10/71



oxygen concentrations were very low.

pH, Free Carbon Dioxide and Total Alkalinity

In the three lakes, surface pH values were higher than in the deeper strata (Table 1). For example, on August 21, 1971 in Opinicon Lake, pH values at 1.0 and 9.0m were 8.5 and 7.4 respectively.

Surface carbon dioxide concentrations in Opinicon and Sand lakes were zero or near-zero while those of the bottom strata ranged from 1.4 to 14.6 mg/l (Table 1). The high deep-water carbon dioxide values as well as the above mentioned depressed pH levels are related to conditions of organic decomposition. In Whitefish Lake, free carbon dioxide was not detected.

In general, alkalinity concentrations were higher in the bottom waters than in the surface strata. For example, on August 22 in Opinicon Lake values at 1.0 and 9.0m were 81.5 and 91.5 mg/l respectively. The higher total alkalinity values in the bottom waters relative to surface concentrations indicate that release of bicarbonate from sediments was occurring by bacterial and chemical action in conjunction with calcium, magnesium, iron, manganese and ammonia.

Hardness, Chloride, Conductivity and Iron

The hardness, chloride and conductivity data (Table 2) were consistent with each other indicating that no unusual mineral characteristics were present. The hardness is such that cottagers may prefer using detergents containing phosphates for washing purposes and if such detergents are used by cottagers, every effort should be made to ensure that the waste disposal systems do not allow any phosphorus to gain access to the lake. The use of soap is highly recommended as an alternative to the use of detergents containing phosphates.

The iron concentrations (Table 2) were uniformly low which is normal for this type of lake.

Kjeldahl Nitrogen and Total Phosphorus

Surface concentrations of Kjeldahl nitrogen and total phosphorus were low and would not be expected to support nuisance levels of algae. There were high concentrations of each in the bottom waters at Station 58 on October 8. This may have been due to recycling from the sediments.

Chlorophyll a

In general, algal densities in Opinicon, Sand and Whitefish lakes as reflected by chlorophyll a concentrations were low during the three surveys (Table 3). Chlorophyll a concentrations in Whitefish Lake were slightly higher than those measured in Opinicon and Sand lakes. The algal levels encountered would not be expected to cause a reduction in water-oriented recreational activities such as swimming and water skiing or diminish the aesthetic quality of the lake.

As indicated above, chlorophyll a measures the amount of photosynthetic green pigment in algae while water clarity which is one of the more important parameters used in defining water quality is determined using a Secchi disc.

Recently, Brown (1972) has indicated that a near-hyperbolic relationship exists between chlorophyll a concentrations and Secchi disc readings for lakes of Precambrian origin. Figure 5 describes the author's mathematical relationship between chlorophyll a and Secchi disc for 945 sets of data collected from approximately sixty recreational lakes which are characterized by high chlorophyll a concentrations and poor water clarity are situated along the vertical axis of the hyperbola while oligotrophic waters which have low chlorophyll a levels and allow significant light penetration lie along the horizontal limb. Mesotrophic lakes would be dispersed about the middle section of the curve. The relatively unproductive nature of the "Opinicon Lakes" is indicated by their proximity to values computed for Lake Ontario and the Eastern Basin of Lake Erie - two oligotrophic to mesotrophic bodies of water. Significantly, Opinicon, Sand and Whitefish lakes are well-removed from the Bay of Quinte, the Western Basin of Lake Erie, Riley Lake and Gravenhurst Bay - four highly enriched lakes.

FIGURE 5

CHLOROPHYLL a - SECCHI DISC RELATIONSHIP

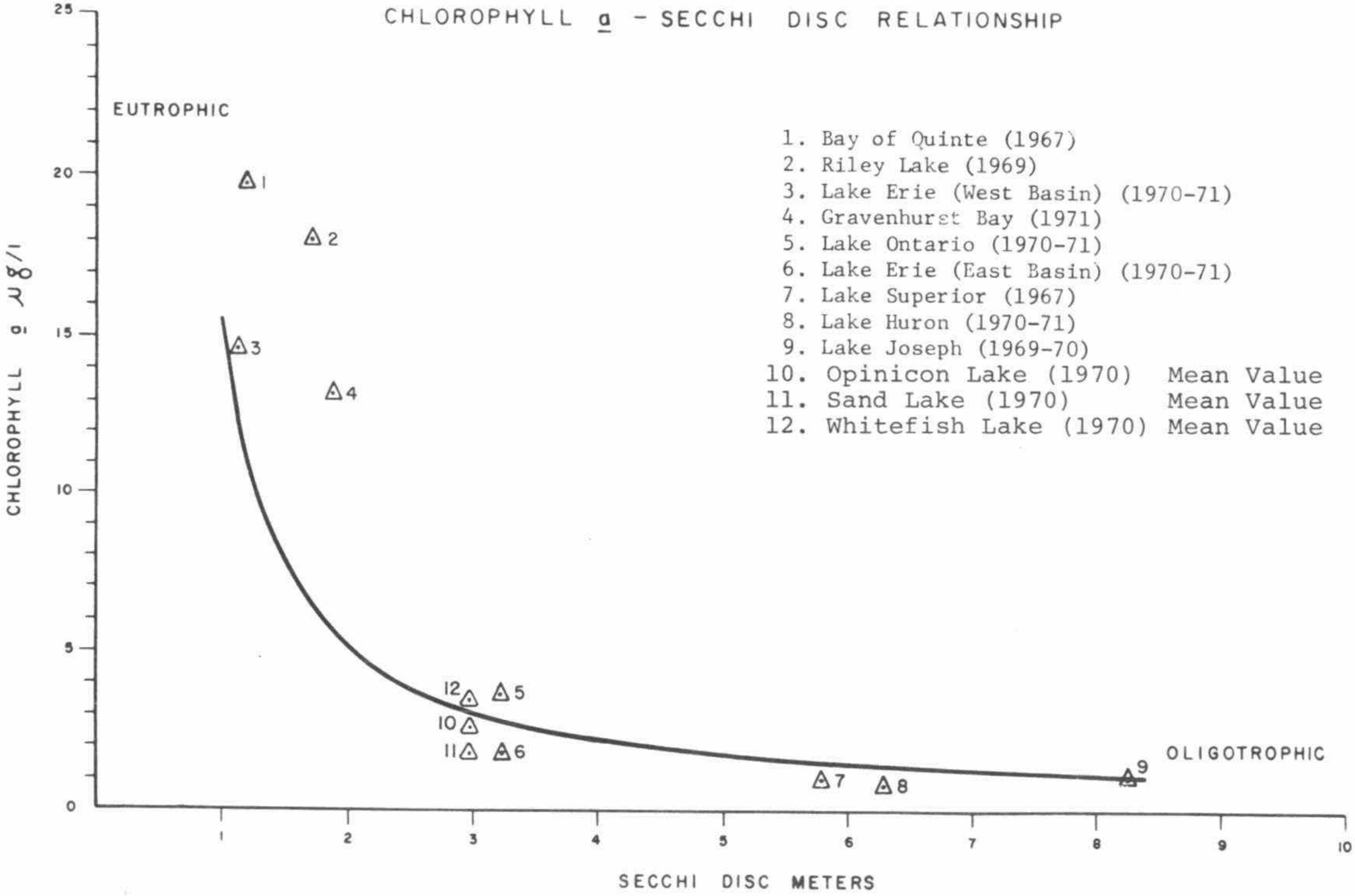


Figure 5: Relationship between chorophyll a and Secchi disc as determined from recreational lakes surveyed in 1971, as well as the mean values for chlorophyll a-Secchi disc for **Opinicon,** Sand and Whitefish Lakes - 1971. Values for the Great Lakes were added for comparative purposes.

Opinicon Lake

Opinicon Lake was well-within the OWRC recreational use criteria (OWRC, 1970) during the three surveys completed.

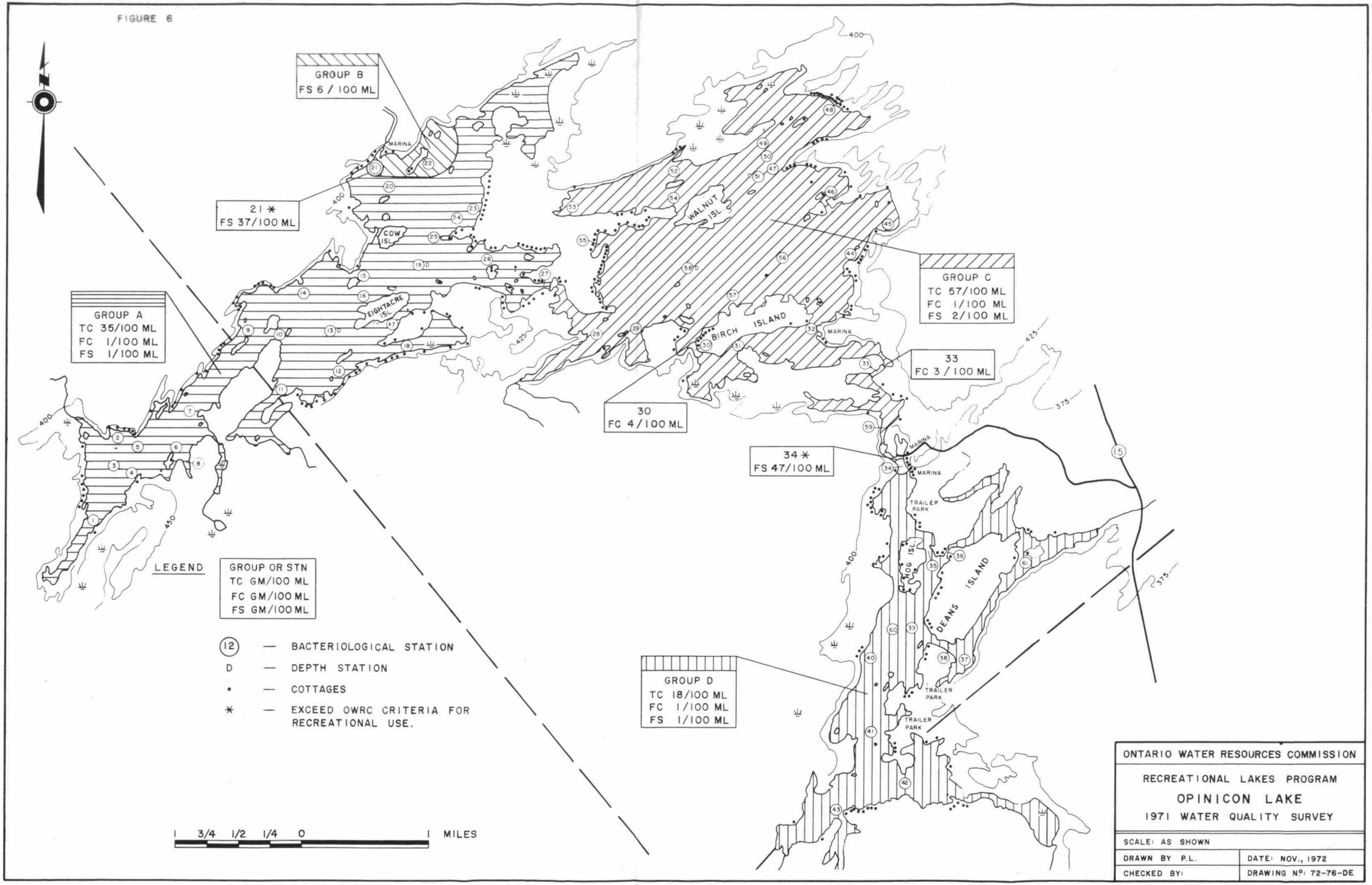
During the June survey, most of the lake, Group A was homogeneous with overall bacterial geometric means of 35 TC/100 ml, 1 FC/100 ml and 1 FS/100 ml, (Figure 6, tables 4, 5, 6). Station 21, at the inflow through Chaffey's Lock, had a significantly higher FS level of 37/100 ml. Group B, (Stations 22 and 22A), east of the lock, also was higher than Group A with 6 FS/100 ml (Figure 6). Similar surveys completed in 1971 on the Newboro Lake area (OWRC, 1971) indicated that the water flowing from Indian Lake into Opinicon Lake was characterized by high FS means. Hence the origin of the high FS levels at Station 21 may be as far upstream as Indian Lake.

In the August survey, all stations were homogeneous for FC and FS with densities of 1 FC/100 ml and 5 FS/100 ml (Figure 7, tables 5 and 6). Opinicon Lake was divided into two areas of different TC concentrations: Group A with 12 TC/100 ml and Group B, south and east of Chaffey's Lock, with 126 TC/100 ml. The Group B area was very shallow, weedy and bordered by a heavily cottaged shoreline. The higher TC levels in Group B may be a result of the inflow or an input from the cottaged shoreline.

In the October survey, all lake stations were included in Group A (Figure 8) with 10 TC/100 ml, 1 FC/100 ml and 2 FS/100 ml except for Station 21, which again had a higher FS level of 23/100 ml.

Opinicon Lake, during the three surveys, was well-within the OWRC recreational criteria. The FC and FS levels remained very low throughout

FIGURE 6



ONTARIO WATER RESOURCES COMMISSION

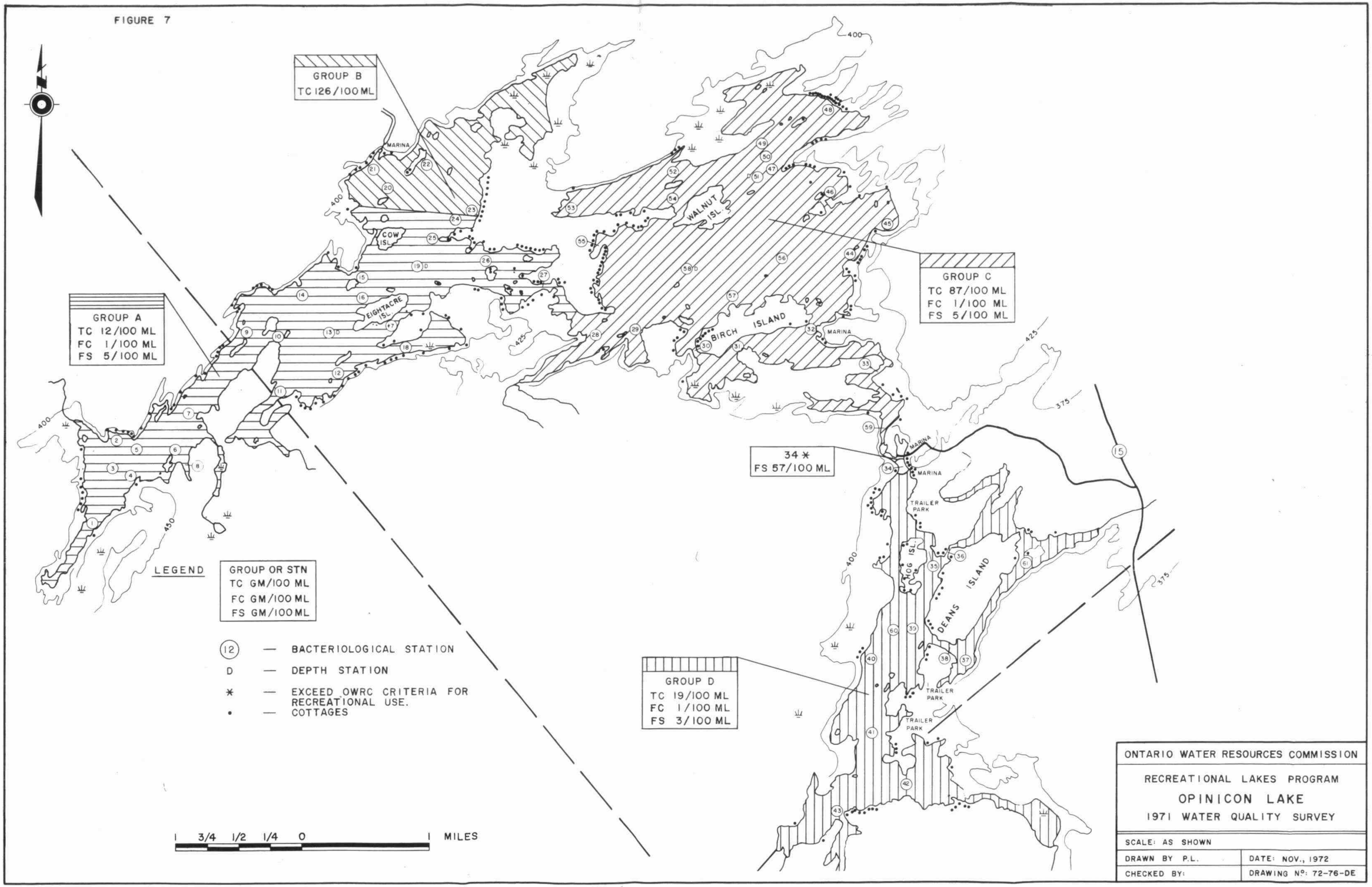
RECREATIONAL LAKES PROGRAM

OPINICON LAKE

1971 WATER QUALITY SURVEY

SCALE: AS SHOWN	
DRAWN BY P.L.	DATE: NOV., 1972
CHECKED BY:	DRAWING Nº: 72-76-DE

FIGURE 7



ONTARIO WATER RESOURCES COMMISSION

RECREATIONAL LAKES PROGRAM

OPINICON LAKE

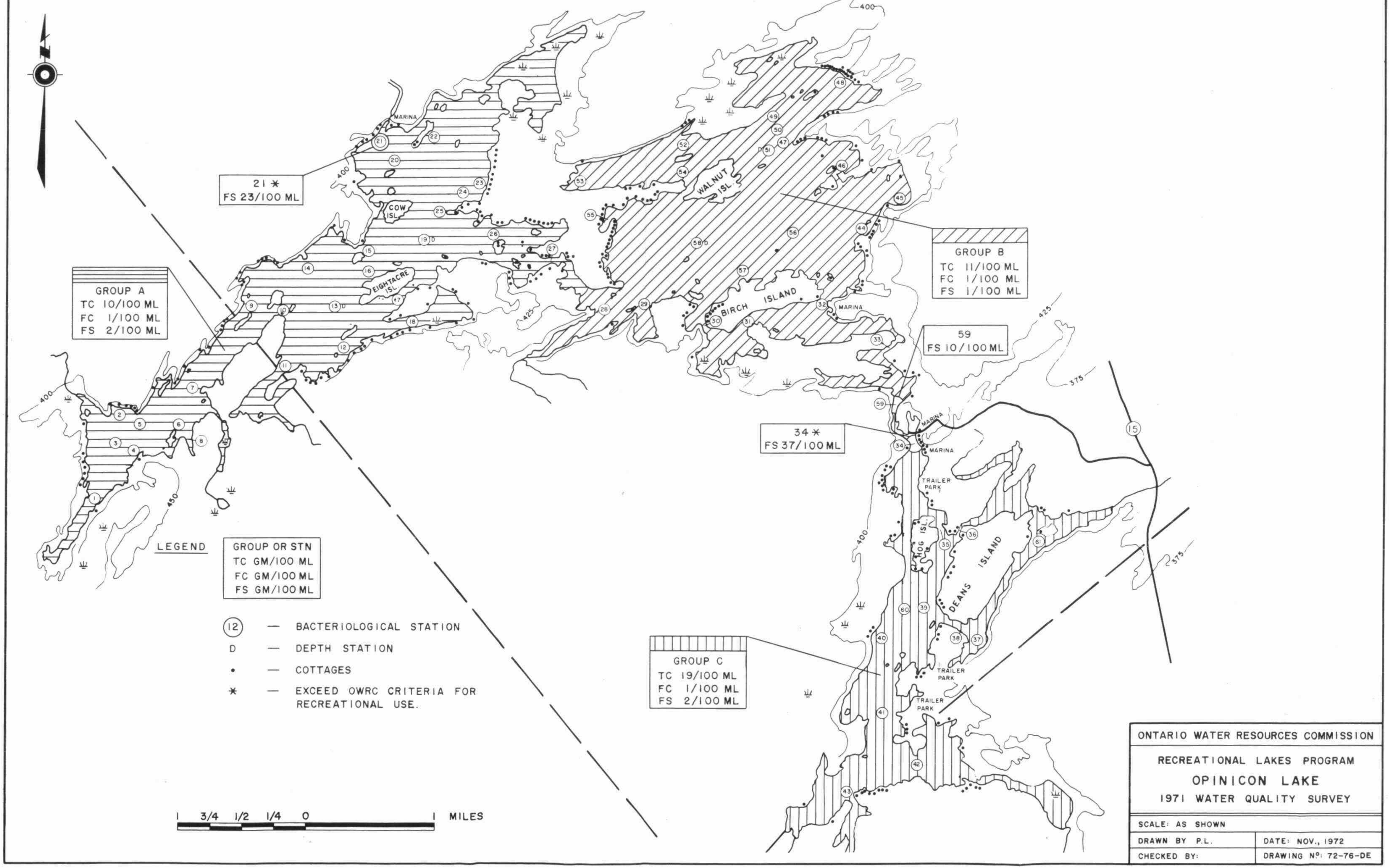
1971 WATER QUALITY SURVEY

SCALE: AS SHOWN

DRAWN BY P.L. DATE: NOV., 1972

CHECKED BY: DRAWING Nº: 72-76-DE

FIGURE 8


GROUP A
TC 10/100 ML
FC 1/100 ML
FS 2/100 ML
GROUP B
TC 11/100 ML
FC 1/100 ML
FS 1/100 ML
GROUP C
TC 19/100 ML
FC 1/100 ML
FS 2/100 ML
21 *
FS 23/100 ML
59
FS 10/100 ML
34 *
FS 37/100 ML
COW ISL.
EIGHTACRE ISL.
WALNUT ISL.
BIRCH ISLAND
HOG ISL.
DEANS ISLAND
MARINA
TRAILER PARK
400
425
450
375
15
LEGEND
GROUP OR STN
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML
12 — BACTERIOLOGICAL STATION
D — DEPTH STATION
• — COTTAGES
* — EXCEED OWRC CRITERIA FOR RECREATIONAL USE.
1 3/4 1/2 1/4 0 1 MILES
ONTARIO WATER RESOURCES COMMISSION
RECREATIONAL LAKES PROGRAM
OPINICON LAKE
1971 WATER QUALITY SURVEY
SCALE: AS SHOWN
DRAWN BY P.L.
DATE: NOV., 1972
CHECKED BY:
DRAWING Nº: 72-76-DE

the three surveys except for Station 21 which exceeded the FS recreational criteria in June and October. The TC levels were significantly higher in June than in August or October, (Table 7), possibly, because of rainfall induced runoff 0.77 inches of rainfall were recorded at Athens Climatological station coupled with the spring snow melt runoff.

Sand Lake

Sand Lake which was surveyed simultaneously with Opinicon Lake, was also well within the OWRC recreational use criteria.

During the June survey, the majority of lake stations were included in Group C (Figure 1) with 57 TC/100 ml, 1 FC/100 ml and 2 FS/100 ml (Tables 8, 9, 10). Stations 30 and 33 had slightly higher FC levels of 4/100 ml and 3/100 ml respectively.

In August, the entire lake was homogeneous, (Group C) with bacterial geometric means of 87 TC/100 ml, 1 FC/100 ml and 5 FS/100 ml (Figure 7, Tables 8, 9, 10). Sand Lake was again uniform in the October survey. All stations except Station 59 were included in Group B with bacterial mean levels of 11 TC/100 ml, 1 FC/100 ml and 1 FS/100 ml (Figure 8). Station 59 had a higher FS density of 10/100 ml

Generally, the FC and FS concentrations remained very low during the three surveys. The TC levels were uniformly low in June and August and even lower in October (Table 11).

Whitefish Lake

Whitefish Lake was well within the OWRC recreational use criteria and generally had uniformly low bacterial levels except for Station 34, which had elevated FS concentrations during all three surveys. In June, the majority of stations were included in Group D (Figure 6) with 18 TC/100 ml, 1 FC/100 ml and 1 FS/100 ml (Tables 12, 13, 14). In August, Group D, encompassing the majority of stations, displayed overall means of 19 TC/100 ml, 1 FC/100 ml and 3 FS/100 ml (Figure 7). Group C, in October, had low bacterial means of 19 TC/100 ml, 1 FC/100 ml and 2 FS/100 ml (Figure 8).

Station 34 had elevated FS levels of 47/100 ml, 57/100 ml and 37/100 ml during the June, August and October surveys, respectively. This station is in a very shallow and weedy area of Whitefish Lake bordered by cottages. These levels, in excess of the OWRC recreational use criteria, have been attributed to rainfall induced runoff from the cottaged shoreline. The Athens Climatological station recorded 0.77 inches of rain during the June survey period, 1.09 inches during August survey and 0.56 inches during the October survey.

TC and FC concentrations remained uniformly low for all surveys completed on Whitefish Lake (Table 15). FS levels remained low but not uniform.

The three lakes had relatively low bacterial levels during the three survey periods. In the June survey, the TC concentrations for Opinicon Lake and Sand Lake were uniformly higher than those in Whitefish Lake. The TC levels in August decreased in Opinicon Lake remained the same in Whitefish Lake and increased in Sand Lake.

By the October survey the TC densities were uniformly low (Table 16).

Although all three lakes were well within the OWRC recreational criteria, all surface water must receive treatment, including disinfection, before it can be considered potable.

Table 1: Extreme and mean data for dissolved oxygen (mg/l), pH, alkalinity (mg/l) and free CO_2 (mg/l) for Opinicon, Sand and Whitefish Lakes, 1971. Data were collected from 1m and from 1m above the sediments.

	Dissolved Oxygen		pH		Alkalinity		Free Carbon Dioxide	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Opinicon								
1m	10.7 - 15.2	13.2	8.0 - 8.5	8.2	79.5 - 92.5	82.0	0.0 - 2.4	0.9
Bottom	0.5 - 15.3	8.6	6.6 - 8.1	7.6	81.0 -100.5	86.7	0.8 -11.9	6.2
Sand								
1m	11.7 - 14.5	13.0	8.0 - 8.4	8.3	78.5 - 87.5	83.5	0.0 - 2.6	N.A.*
Bottom	0.0 - 1.6	0.7	7.0 - 7.5	7.3	84.0 -116.5	101.2	6.8 -14.6	11.3
Whitefish								
1m	11.7 - 17.4	13.7	8.3 - 8.7	8.5	81.0 - 88.5	88.5	0.0 - 3.08	N.A.*
Bottom	5.2 - 16.4	11.0	8.1 - 8.7	8.4	79.0 - 89.0	83.9	0.0 - 0.0	0.0

* Not applicable - only two values

Table 2

Iron, Hardness (Hard), Total Phosphorus (P), Total Kjeldahl Nitrogen (N), Chloride (Cl) and Conductivity (Cond) for Opinicon Lake, 1971.

Results are expressed in mg/1 except conductivity which is umhos/cm^3.

Station	Depth	Date	Iron	Hard.	P	N	Cl	Cond.
13	4m comp	26/6	0.10	90	0.022	0.38	4	185
13	6m comp	8/10	0.05	88	0.018	0.48	4	-
13	8m	8/10	0.05	-	0.016	0.45	-	-
21	1m	27/6	0.05	96	0.026	0.42	5	199
21	1m	19/8	0.05	98	0.014	0.43	6	202
43	1m	27/6	0.05	92	0.024	0.39	5	188
58	6.2m comp	26/6	0.05	92	0.022	0.40	4	190
58	8m comp	19/8	0.05	92	0.017	0.37	8	189
58	14m	19/8	-	-	0.064	0.34	-	-
58	6m comp	8/10	0.05	90	0.020	0.47	3	-
58	13m	8/10	0.05	-	0.23	1.7	-	-
59	1m	19/8	0.05	90	0.014	0.42	4	186
60	6m comp	26/6	0.05	92	0.024	0.31	4	189
60	5m comp	19/8	0.05	86	0.026	0.49	4	170
60	m	19/8	-	-	0.020	0.38	-	-
60	4m comp	8/10	0.05	90	0.020	0.53	3	-
60		8/10	0.05	-	0.022	0.48	-	-

= "less than"

"comp" means a composite sample taken through the depth indicated.

Table 3: Chlorophyll a and Secchi disc values for Opinicon, Sand and Whitefish Lakes, Stations 13, 58 and 60 respectively, during 1971.

DATE	OPINICON LAKE #13		SAND LAKE #58		WHITEFISH LAKE #60	
	Chloro a	S.D.	Chloro a	S.D.	Chloro a	S.D.
June 25	2.3 ug/l	m	1.4 ug/l	m	1.4 ug/l	m
June 26	1.1		1.2		1.8	
June 27	1.4		1.0		5.5	
June 28	1.9		1.1		3.1	
August 15	6.1	2.5	3.1	2.5	5.2	2.0
August 19	3.0	3.0	1.7	3.4	3.3	5.0
August 21	3.5	3.5	2.6	4.0	8.3	2.5
August 22	-	-	2.9	2.0	4.9	2.0
October 5	1.8	3.0	1.0	3.0	1.2	3.0
October 6	3.1	3.0	0.9	3.0	2.8	3.0
October 7	2.5	3.0	1.9	3.0	1.5	3.0
October 8	2.7	3.0	2.2	3.0	2.4	3.0
October 9	2.8	2.5	1.1	3.0	-	-
Mean	2.7	2.9	1.7	2.9	3.4	2.9

EXPLANATION OF TERMS IN BACTERIOLOGICAL TABLES

F - the calculated analysis of variance statistic on F ratio.

df - degrees of freedom of the F ratio for "between group" and "within group" variation.

F(5%) - the F ratio from a statistics table (Rohlf 1969). If the calculated F is greater than the F(5%), a significant difference (SD) occurred between the groups in the analysis. If the F is less than F(5%), no significant difference (NSD) occurred.

log GM - the logarithm (base 10) of the geometric mean.

S.E. - the standard error of the log GM where

$$S.E. = \frac{s}{\sqrt{n}} \quad \text{and } s = \text{standard deviation}$$

N - the number of values in the mean.

GM - the geometric mean of the bacterial level.

t - the calculated test of significance or student t-test used to compare stations, groups and a survey.

If t for the number of degrees of freedom shown is greater than the critical t value, a significant difference (SD) occurs.

SD refers to a significant difference at the .05 level but no significant difference at the .01 level.

SD* refers to a significant difference at the .01 level but no significant difference at the .001 level.

SD** refers to a significant difference at the .001 level.

Table 4 - Opinicon Lake

Summary of Analysis of Variance Grouping of Stations

Parameter - Total Coliform (TC)/100 ml

SURVEY	JUNE 24 - 28	AUGUST 19 - 23	OCTOBER 5 -9
Group	All Stations	All Stations	All Stations
F	.902	2.419	1.0978
df	29, 116	29, 119	19, 77
F(.05)	1.573	1.570	1.75
	NSD	SD	NSD
Group	A	A	A
	All Stations	All stations except 20, 21, 22, 22A, 23	All Stations
F		.9978	
df		24, 99	
F(.05)		1.61	
		NSD	
log GM	1.5427	1.0781	1.0023
SE	.0797	.0703	.0737
N	146	124	97
GM	35	12	10
Group		B	
		Stations 20, 22, 22A, 23	
F		.4362	
df		4, 18	
F(.05)		2.93	
		NSD	
log GM		2.1003	
SE		.1175	
N		23	
GM		126	

Table 5 - Opinicon Lake

Summary of Analysis of Variance Grouping of Stations

Parameter - Fecal Coliform (FC)/100 ml

SURVEY	JUNE 24 - 28	AUGUST 19 - 23	OCTOBER 5 -9
Group	All Stations	All Stations	All Stations
F	1.495	.817	1.3020
df	29, 117	29, 119	19, 79
F(.05)	1.572	1.570	1.75
	NSD	NSD	NSD
Group	A	A	A
	All stations	All stations	All stations
log GM	.0205	.0497	.0213
SE	.0060	.0135	.0099
N	147	149	99
GM	1	1	1

Table 6 - Opinicon Lake

Summary of Analysis of Variance Grouping of Stations

Parameter - Fecal Streptococcus (FS)/100 ml

SURVEY	JUNE 24 - 28	AUGUST 19 - 23	OCTOBER 5 -9
Group	All Stations	All Stations	All Stations
F	6.091	1.318	2.0469
df	29, 117	29, 119	19, 79
F(.05)	1.572	1.570	1.75
	SD	NSD	SD
Group	A	A	A
	All stations except 21, 22, 22A	All stations	All stations except 21
F	1.4996		.6673
df	26, 105		18, 75
F(/05)	1.61		1.75
	NSD		NSD
log GM	.1393	.6723	.2699
SE	.0264	.0607	.0449
N	132	140	94
GM	1	5	2
Group	Station 21		Station 21
log GM	1.5640		1.3630
SE	.1683		.2539
N	5		5
GM	37		23
Group	B		
	Stations 22, 22A		
F	t = 1.5609		
df	8		
F(.05)	2.306		
	NSD		
log GM	.7674		
SE	.1556		
N	10		
GM	6		

Table 7

Summary of t - tests between Analysis of Variance Groupings of Stations Between Surveys for Opinicon Lake

a - total coliform

AUGUST
t = 4.2993
JUNE df = 268 S.D.**
t(.05) = 1.96

OCTOBER
t = .7374
AUGUST df = 219 NSD
t(.05) = 1.96

OCTOBER
t = 4.7080
JUNE df = 241 SD***
t(.05) = 1.96

b - fecal coliform

AUGUST
t = 1.9675
JUNE df = 294 SD
t(.05) = 1.96

OCTOBER
t = 1.5410
AUGUST df = 246 NSD
t(.05) = 1.96

OCTOBER
t = 0.0732
JUNE df = 244 NSD
t(.05) =1.96

c - fecal streptococcus

AUGUST
t = 7.711
JUNE df = 279 SD**
t(.05) = 1.96

OCTOBER
t = 4.7696
AUGUST df = 241 SD**
t(.05) = 1.96

OCTOBER
t = 2.6587
JUNE df = 224 SD**
t(.05) = 1.96

Table 8 - Sand Lake

Summary of Analysis of Variance Grouping of Stations

Parameter - Total Coliform (TC)/100 ml

SURVEY	JUNE 24 - 28	AUGUST 19 - 23	OCTOBER 5 -9
Group	All Stations	All Stations	All Stations
F	.533	.8495	.7810
df	23, 93	23, 92	18, 72
F(.05)	1.651	1.61	1.75
	NSD	NSD	NSD
Group	C	C	B
	All stations	All stations	All stations
log GM	1.7572	1.9408	1.0404
SE	.0873	.0895	.0827
N	117	116	91
GM	57	87	11

Table 9 - Sand Lake

Summary of Analysis of Variance Grouping of Stations

Parameter - Fecal Coliform (FC)/100 ml

SURVEY	JUNE 24 - 28	AUGUST 19 - 23	OCTOBER 5 -9
Group	All Stations	All Stations	All Stations
F	2.301	.7119	1.1112
df	23, 93	23, 91	18, 73
F(.05)	1.651	1.61	1.75
	SD	NSD	NSD
Group	C	C	B
	All stations except 30, 33	All stations	All stations
F	1.6524		
df	21, 86		
F(.05)	1.87		
	NSD		
log GM	.1069	.1149	.0281
SE	.0215	.0356	.0123
N	108	115	92
GM	1	1	1

Table 10 - Sand Lake

Summary of Analysis of Variance Grouping of Stations

Parameter - Fecal Streptococcus (FS)/100 ml

SURVEY	JUNE 24 - 28	AUGUST 19 - 23	OCTOBER 5 -9
Group	All Stations	All Stations	All Stations
F	1.459	.8584	2.9593
df	23, 93	23, 89	18, 68
F(.05)	1.651	1.61	1.75
	NSD	NSD	SD
Group	C	C	B
	All stations	All stations	All stations except 59
F			.6250
df			17, 64
F(.05)			1.84
			NSD
log GM	.2165	.6665	.1206
SE	.0338	.0695	.0259
N	117	113	82
GM	2	5	1

Table 11

Summary of t-tests between Major Analysis of Variance Grouping of Stations Between Surveys for Sand Lake

a - total coliform

	AUGUST		OCTOBER		OCTOBER
JUNE	t = .1845 df = 231 NSD t(.05) = 1.96	AUGUST	t = 7.2137 df = 205 SD** t(.05) = 1.96	JUNE	t = 5.8291 df = 205 SD** t(.05) = 1.96

b - fecal coliform

	AUGUST		OCTOBER		OCTOBER
JUNE	t = .1894 df = 221 NSD t(.05) = 1.96	AUGUST	t = 2.1011 df = 205 SD t(.05) = 1.96	JUNE	t = 3.0402 df = 198 SD* t(.05) = 1.96

c - fecal streptococcus

	AUGUST		OCTOBER		OCTOBER
JUNE	t = 5.8848 df = 228 SD** t(.05) = 1.96	AUGUST	t = 0.4552 df = 193 SD** t(.05) = 1.96	JUNE	t = 2.0919 df = 197 SD t(.05) = 1.96

Table 12 - Whitefish Lake

Summary of Analysis of Variance Grouping of Stations

Parameter - Total Coliform (TC)/100 ml

SURVEY	JUNE 24 - 28	AUGUST 19 - 23	OCTOBER 5 - 9
Group	All Stations	All Stations	All Stations
F	1.427	.9219	.4414
df	11, 43	10, 43	7, 31
F(.05)	2.026	2.08	2.33
	NSD	NSD	NSD
Group	D	D	C
	All stations	All stations	All stations
log GM	1.2573	1.2872	1.2772
SE	.0694	.0914	.1253
N	55	54	39
GM	18	19	19

Table 13 - Whitefish Lake

Summary of Analysis of Variance Grouping of Stations

Parameter - Fecal Coliform (FC)/100 ml

SURVEY	JUNE 24 - 28	AUGUST 19 - 23	OCTOBER 5 -9
Group	All Stations	All Stations	All Stations
F	1.178	.9688	1.7714
df	11, 43	10, 44	7, 32
F(.05)	2.026	2.08	2.33
	NSD	NSD	NSD
Group	D	D	C
	All stations	All stations	All stations
log GM	.1067	.0397	.0226
SE	.0375	.0345	.0127
N	55	55	40
GM	1	1	1

Table 14 - Whitefish Lake

Summary of Analysis of Variance Grouping of Stations

Parameter - Fecal Streptococcus (FS)/100 ml

SURVEY	JUNE 24 - 28	AUGUST 19 - 23	OCTOBER 5 - 9
Group	All Stations	All Stations	All Stations
F	10.460	3.140	4.0269
df	11, 43	10, 44	7, 32
F(.05)	2.026	2.08	2.33
	SD	SD	SD
Group	D	D	C
	All stations except 34	All stations except 34	All but station 34
F	.7099	.7394	.3073
df	9, 40	9, 40	6, 28
F(.05)	2.12	2.12	2.45
	NSD	NSD	NSD
log GM	.1385	.4363	.2973
SE	.0440	.0811	.0743
N	50	50	35
GM	1	3	2

Table 15

Summary of t-tests Between Major Analysis of Variance Groupings Between Surveys for Whitefish Lake

a - total coliform

	AUGUST		OCTOBER		OCTOBER
JUNE	t = .2612 df = 107 NSD t(.05) = 1.98	AUGUST	t = .0992 df = 91 NSD t(.05) = 1.98	JUNE	t = .1114 df = 92 NSD t(.05) = 1.98

b - fecal coliform

	AUGUST		OCTOBER		OCTOBER
JUNE	t = 1.3149 df = 108 NSD t(.05) = 1.98	AUGUST	t = .4078 df = 93 NSD t(.05) = 1.98	JUNE	t = 1.8547 df = 93 NSD t(.05) = 1.98

c - fecal streptococcus

	AUGUST		OCTOBER		OCTOBER
JUNE	t = 3.2296 df = 98 SD* t(.05) = 1.98	AUGUST	t = 1.2064 df = 83 NSD t(.05) = 2.00	JUNE	t = 1.9517 df = 83 NSD t(.05) = 2.00

Table 16

Summary of t-tests Between Analysis of Variance Grouping of Stations Between Opinicon Lake, Sand Lake and Whitefish Lake for Total Coliform

	JUNE SURVEY	AUGUST SURVEY	OCTOBER SURVEY
	Opinicon	Opinicon	Opinicon
Sand	t = 1.811 df = 261 NSD t(.05) = 1.96	t = 7.633 df = 238 SD** t(.05) = 1.96	t = .345 df = 186 NSD t(.05) = 1.96
	Whitefish	Whitefish	Whitefish
Sand	t = 3.674 df = 170 SD** t(.05) = 1.96	t = 4.407 df = 168 SD** t(.05) = 1.96	t = 1.539 df = 128 NSD t(.05) = 1.98
	Whitefish	Whitefish	Whitefish
Opinicon	t = 2.086 df = 199 SD t(.05) = 1.96	t = .555 df = 176 NSD t(.05) = 1.96	t = 1.918 df = 134 NSD t(.05) = 1.98

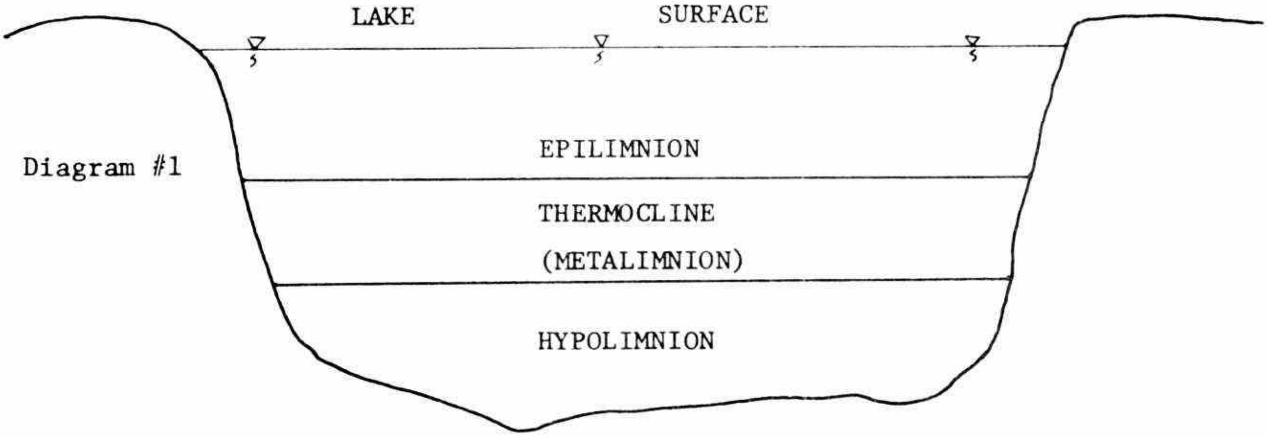
GLOSSARY OF TERMS

ALKALINITY	:The alkalinity of a water sample is a measure of its capacity to neutralize acids. This capacity is due to carbonate, bicarbonate and hydrozide ions and is arbitrarily expressed as if all of the neutralizing capacity was due to calcium carbonate alone.
ANOXIC	:Refers to conditions when no oxygen is present.
BACKGROUND COLONIES	:Background colonies are other lake water bacteria capable of growing on the total coliform plate, in spite of the inherent restrictive conditions.
CHLORIDE	:Chloride is simply a measure of the chloride ion concentration and is not a measure of chlorination.
CHLOROPHYLL *a*	:A green pigment in plants.
CONDUCTIVITY	:Conductivity is a measure of the waters ability to conduct an electric current and is due to the presence of dissolved salts.
DIATOMS	:Unicellular plants found on all continents and in all types of water where light and nutrients are sufficient to support photosynthesis. They are comprised of two siliceous frustules (cell walls) which have an outer valve (epitheca) fitting over the inner valve (hypotheca) like the lid on a box. The siliceous deposits comprising the frustules vary in regular patterns according to the individual species.
EPILIMNION	:Is the thermally uniform layer of a lake lying above the thermocline. Diagram I.
EUPHOTIC ZONE	:The lighted region that extends vertically from the water surface to the level at which photosynthesis fails to occur due to insufficient light penetration.
EUTROPHIC	:Waters containing advanced nutrient enrichment and characterized by a high rate of organic production.

EUTROPHICATION	:The process of becoming increasingly enriched in nutrients. It refers to the entire complex of changes which accompanies increasing nutrient enrichment. The result is the increased production of dense biological growths such as algae and aquatic weeds which generally degrade water quality and render the lake unsuitable for many recreational activities.
FECAL COLIFORMS (FC)	:Fecal coliforms are bacteria associated with recent fecal pollution from man and animals.
FECAL STREPTOCOCCUS (FS)	:Fecal streptococcus are bacteria associated with fecal pollution from animals and to a lesser extent man.
HARDNESS	:Hardness of water is a measure of the total concentration of calcium and magnesium ions expressed as if all of the ions were calcium carbonate.
HYPOLIMNION	:The uniformly cold and deep layer of a lake lying below the thermocline, when the lake is thermally stratified. Diagram #1
KJELDAHL NITROGEN	:Sum of nitrogen present in the ammonia and organic forms (it does not include nitrite or nitrate).
MESOTROPHIC	:Waters characterized by a moderate nutrient supply and organic production (i.e. midway between eutrophic and oligotrophic).
METALIMNION	:See thermocline.
OLIGOTROPHIC	:Waters containing a small nutrient supply and consequently characterized by a low rate of organic production.
pH	:Is the measure of the hydrogen ion concentration expressed as the negative logarithm of the molar concentration.
PHOSPHORUS (TOTAL)	:Sum of all forms of phosphorus present in the sample.

SECCHI DISC	:A circular metal plate, 20 centimeters in diameter, the upper surface of which is divided into four equal quadrants. Two quadrants directly opposite each other are painted black and the intervening ones white. The secchi disc is used to estimate the turbidity of the lake water.
THERMAL STRATIFICATION	:During the spring, vertical temperatures in a lake are homogeneous from top to bottom. As summer advances, the surface waters become warmer and less dense than the underlying cooler waters. A strong thermal gradient (Thermocline) occurs giving rise to three distinct water layers. The variation in density between layers retards mixing by wind action and water currents. Diagram #1.
THERMOCLINE (metalimnion)	:The layer of water located between the epilimnion and hypolimnion in which the temperature exhibits a decline equal to or exceeding 1°C increase per meter.

Diagram #1



TOTAL COLIFORMS (TC)	:Total coliforms are bacteria commonly associated with fecal pollution but may also be present naturally in the environment.
TROPHIC STATUS	:Depending upon the degree of nutrient enrichment and resulting biological productivity, lakes are classified into three intergrading types:

TROPHIC STATUS (continued)

:oligotrophic, mesotrophic and eutrophic. If the supply of nutrients to an oligotrophic lake is progressively increased, the lake will become more mesotrophic in character and with continued enrichment it will become eutrophic.

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> Microbiological Criteria
> Water used for body contact recreational activities should be free from pathogens including any bacteria, fungi or viruses that may produce enteric disorders or eye, ear, nose, throat and skin infections. Where ingestion is probable, recreational waters can be considered impaired when the coliform, fecal coliform, and/or enterococcus geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively, in a series of at least ten samples per month, including samples collected during weekend periods.

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